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Influence of Farm Machinery

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THE INFLUENCE OF FARM MACHINERY:

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GROWTH IN USE OF MACHINERY.

Many comparisons have been made between present agricultural conditions and the agricultural conditions at different stages in the early years of our colonial and national life. I shall attempt, in the first of this paper, not to trace out rather to indicate the progressive development in the use of farm machinery.

Before the time of the Declaration of Independence the rudest farm machines, or rather implements, were in use. All small grain was cut with hand sickles and threshed by the treading of cattle or horses as in the days of ancient Egypt. The people seem for the most part not to have thought of advantages to be gained by the use of machinery. Everywhere there was a prejudice against inventions. When the first cast-iron plow was made in this country the people objected to its use because it "poisoned the land, injured the fertility and promoted the growth of weeds." Nor were objections to "new fangled notions" to be found only in the New World. The Scotchmen of that time protested against the use of a fanning mill because, they said, it "made a wind where the Lord had made a calm." English and Continental farmers were but little if any further advanced, in the application of machine power than were American farmers. Indeed, it seems fairly certain that in this respect they have learned a great deal more from us than we have learned from them.

During the first decades of our national life many different forms of plows were invented and our present form of stirring-plow

was pretty well developed. But in other lines of farm machinery no inventions that could be called types of present machines were brought to light until about 1850. The first patent for a threshing machine was issued in 1803. Two-horse corn cultivators did not appear until about 1861. Even so late as 1826, if we may credit the statement of a writer in the U. S. Agricultural Report for 1866, an American farmer could have carried all the tools required for a farm of ordinary size, in an ox cart, at one load. "Then a cradle worth $2.50 and a rake worth 25¢, a flail worth 50¢ and a fan for cleaning the grain worth $1.00, was about all that was required." The stock of farm implements and machinery in use in this country in 1859 was worth, on an average, only $1.50 per acre, of cultivated land. Certain it is that our present enormous stock of farm machinery is almost wholly the outgrowth of the last seventy five years.

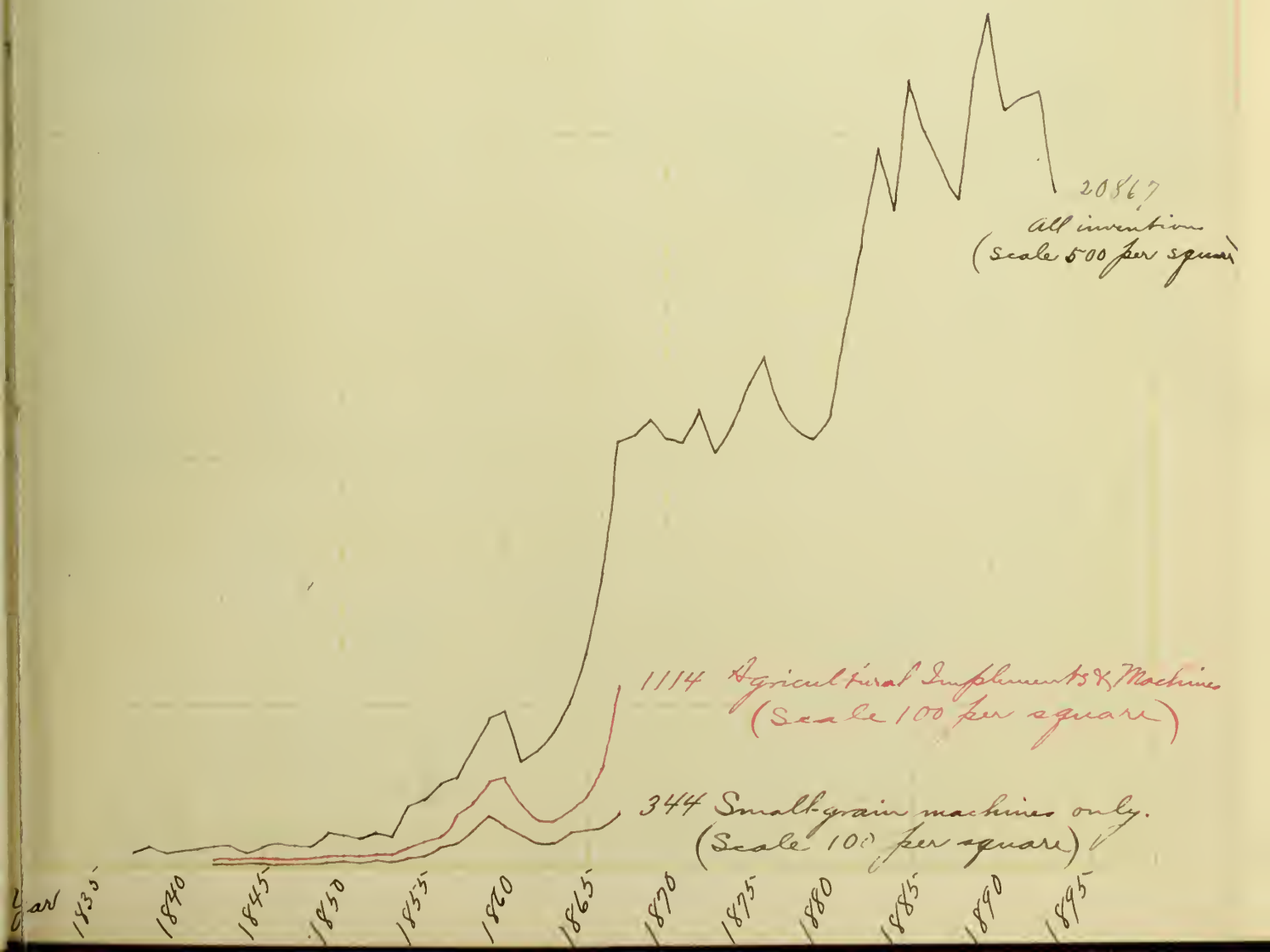
Inventions are seldom made except in response to some want. Necessity, backed by an effectual demand, is the real mother of invention. We may therefore pretty safely infer changes in the use of agricultural machinery during any period, from the record of the inventions of such machinery during that period.

The total number of patents issued for agricultural implements and machinery during the sixty years following 1790 was only 1956, or hardly 32 patents per year. In 1842 only 22 patents for agricultural implements and machines were issued. In 1845 they numbered 24; in 1846, 40; in 1849, 61; in 1850, 68. In 1852 and the following years

in order of succession, the number of patents issued for agricultural implements and machines runs 67, 77, 110, 137, 190, 316, 396, till 1859 when the number issued was 553. Then the energies of our people were given a new turn by the events of the Civil War and inventions for production appear to have been supplanted by inventions for destruction. The patent office record of agricultural implements and machine inventions for the years 1860-1867 is as follows,- 545, 391, 275, 274, 357, 461, 620, 1117. The rapid fall during the first years of the war is more than equalled by the rapid rise immediately after its close. It is worthy of notice that patents for small-grain machinery fell away more rapidly and recovered more slowly than for other kinds of farm machinery. The number of small-grain machine patents fell from 329 in 1859 to 165 in 1862 and did not regain the earlier height until 1867. So far as I have been able to compare the statistics of patents for agricultural implements and machines with those for all inventions, i. e. from 1842 to 1867, the relative rise and fall for the several years is almost identical. In absence of better evidence we may infer, I think, that that relation has continued. The number of patents for all inventions in 1842 was 517; in 1850 it was 993; in 1860, 4819. It fell during the war to 3540. But it rose rapidly and in 1867 was 13,015. There is a noticeable falling off in 1871 and again in 1878. But, in general, there was a steady rise from 1867 to 1885, when the number of patents reached 22,353. Since 1885 there have been great fluctuations. The highest number appears in

1890, 26,292, being nearly double what it was in 1870 and nearly five times what it was in 1860.

Progress of inventions as shown by number of patents issued.
(Compiled from reports of U.S. Patent Office)



The foregoing showing of Patent Office statistics for all inventions is fairly indicative of the growth in use of machinery in any business which, like that of farming, covers the whole period. For the rise and fall of inventions corresponds closely to the rise and fall of the corresponding industrial activity.

As to the number of the different farm machines in the country from which to estimate the amount of machine power in use, nothing but the roughest guess seems possible. The census of 1890 gives figures of certain agricultural machines manufactured in 1889 as follows; plows, 1,249,345; corn planters, 132,140; corn shellers, 91,164; harrows, 268,965; cultivators, 445,490; harvesters and reapers, 8,854; grain cradles, 84,222; threshers, 11,367. But there is nothing to show how long one of these machines would last, how much one of them would do in a season, or the time within which the ~~output~~ number manufactured in any year was sold to the farmers. If we accept the popular estimate that one man with a two horse cultivator should tend 30 acres of corn in a season, and divide this number into the corn acreage, 80,095,051, we will get 2,669,835 as the number of cultivators necessarily used to tend the corn crop of 1897. An estimate of the amount of days' labor of men with hoes, which is replaced by these cultivators, might give some idea of the man-power in this particular class of machines, but similar estimates of the work of other machines would be even less accurate and much less satisfactory. We have, however, a basis for computing the actual labor done by these machines without regard to their

numbers or the different periods of time the several machines were in operation:

MACHINERY AND PRODUCTION.

The Thirteenth Annual Report of the Department of Labor gives statistics of the production of various farm products by present methods and also by more primitive methods, before the use of machines became general. From this we learn that to produce one bushel of "yellow corn, husked, stalks left in field," using a 2-horse breaking plow, harrow for pulverizing before and after planting, a shovel plow for marking check rows, a bucket and hoes for planting, shovel plow for cultivating the corn and wagon and husking peg for gathering, required in 1855 an expenditure of man-labor amounting to 31-three hundred twentieths of a day. To produce the same product by means of gang plow, disk harrow, corn planter, tooth-harrow, cultivators, wagon and husking pegs required, in 1894, 1515-forty thousandths of a day, man-labor. On this basis the man-labor power devoted to the production of corn in 1894 was equal to 45,875,025 days-work of one man. Other things being equal, this labor-power by methods of 1855 could have produced only 473,528,000 bushels of corn. But the corn crop of 1894 was in fact 1,212,770,052 bushels. The difference between these two amounts is 739,242,052 bushels or 60.9 per cent of the crop, which, waiving differences in character of lands and seasons, was due, directly or indirectly, to the use of machinery.

Similar calculations for wheat, oats, rye, barley, potatoes and

nav yield the following tables,-

fraction of a days-work (man-labor) required to produce one

ousnel of

Wheat,	metnod of	1829-30,	713-2400;	metnod of	1895-6,	199-12000.
Rye,	"	"	1847-48	3779-150000;	"	"	1894-5,	151-1500.
Oats,	"	"	1850,	53-320;	"	"	1893,	17-1200.
Corn,	"	"	1855,	51-320;	"	"	1894,	1513-40000.
Potatoes,	"	"	1866,	1427-26400;	"	"	1895,	2279-152000.
Barley,	"	"	1829-30,	763-3600;	"	"	1895-6,	9-1000.
1 Ton Hay	"	"	1850,	253-120;	"	"	1895,	473-1200.

Number of days work expended in the production of the

Corn crop of	1894	by the methods of	1894,	45,873,025
Wheat	"	"	1896	"	"	"	"	1895-6,	7,092,419
Oats,	"	"	1893	"	"	"	"	1893,	9,050,445
Rye,	"	"	1895	"	"	"	"	1894-5,	2,739,145
Barley,	"	"	1896	"	"	"	"	1895-6	627,256
Potatoes	"	1895	"	"	"	"	1895,	5,131,852
Hay	"	"	1895	"	"	"	"	1895,	18,256,783
							Total--	88,770,925

	Crop of		Same expenditure of labor would have produced by methods of		Due to Machinery		
Corn	1894	1212770052 bu.	1855	473528000 bu.	739242052 bu.	60.9%
Wheat	1896	427684346 "	1829-30	23873500 "	403810846 "	94.4%
Oats	1893	638854850 "	1830	54644184 "	584210666 "	91.4%
Rye	1895	27210070 "	1847-48	10872499 "	16337571 "	60.0%
Barley	1896	69695223 "	1829-30	2959530 "	66735693 "	95.7%
Potato	1895	297237370 "	1866	94941060 "	202296310 "	68.0%
Hay	1895	47078541 ton	1850	8659343 ton	38419198 ton	81.6%

It will be noticed from the foregoing table that the portion of product due to the use of improved machinery varies with the different crops from 60.7% to 95.7%. The true average percent is better indicated by the amount of day's-work saved by the use of machinery, and this, we shall find further along, is 81.5%. We may say then, other things being equal, that in 1895 at least 80% of the yield of the above named crops was due to the use of machinery. In other words, during the period from about 1830 to about 1895, the application of machinery to the production of the above named crops, enabled us to make man-labor at least five times as efficient as it was at the beginning of that period.

It will be noticed that the high percentages of machine work appear in the production of wheat, oats and barley--the lowest percentage for these cereals being 91.4%. The data for the hand method experiments in these crops antedate by nearly two decades the data for the corresponding experiments in the other crops. It must not, however, be assumed that the earlier date for the hand method statistics in these cases is in any very considerable degree to be associated with the higher percentages. The data for each comparison in all of the crops that have been considered are from very simple methods, where only tools or implements were used, as against the methods of about 1895. The time element is not important. The percent column is therefore an approximately correct showing of the relative efficiency of the machinery used in the production of the above named

crops. The small grains, and especially barley, must be cared for quickly at the harvest time. Potatoes and corn, on the other hand, may be gathered more at leisure. Herein lies the real reason for the differences. In the production of the breadstuffs alone, machinery has increased the effective power of man labor not five times only, but a little more than ten times, since 1850.

Some idea of whence the increased efficiency arises may appear more clearly from a few illustrations. To shell one bushel of corn by hand method requires 100 minutes of time. To shell one bushel of corn by steam sheller requires only one minute of time. To cut, bind, thresh and clean one acre of wheat, yielding twenty bushels, by means of sickles and flails, requires fifty and two-thirds hours of man-labor. With a combined harvester and thresher only one hour is needed. Two men with a self-binder will cut and shock fifteen acres of wheat in a day. But to do the same work in the same time by the use of hand sickles would require forty-five men. The binding attachment alone does the work of five ordinary men. On the basis of 15 acres per day, for a self-binder, to have put up the wheat crop of 1897 in the same time by hand method would have required a force of 118,395,180 men. The total population of the United States, male and female over ten years of age, as given by the Census of 1890 was only 47,413,559. The purely agricultural population was less than eight and one-half millions.

PRODUCTION AND PRICES.

The effect of this greatly increased production on the prices of farm products is rather a matter for the imagination than for definite showing by statistics.

Farm products are, for the most part, necessaries of life for which price is no adequate measure. Mill in his "Principles of Political Economy" says: "If the article is a necessary of life, which, "rather than resign, people are willing to pay for at any price, a "deficiency of one-third may raise the price to double, triple, or "quadruple." Tooke, in his "History of Prices," says: "The price of "corn in this country (England) has risen from 100 to 200 per cent "and upwards, when the utmost computed deficiency of the crops has "not been more than between one-sixth and one-third below the average "and when the deficiency has been relieved by foreign supplies." Marshall says: "We know that a fall in the price of the quartern loaf "from 6d to 4d has scarcely any effect in increasing the consumption "of bread. With regard to the other end of the scale it is more difficult to speak with certainty because there has been no approach to "a scarcity in England since the repeal of the corn laws. But availing ourselves of a less happy time, we may suppose that deficits in "the supply of 1, 2, 3, 4 or 5 tenths would cause a rise in price of "3, 8, 16, 28 or 45 tenths respectively."

It has been shown above (page 8) that the corn crop of 1894 was 1,212,770,052 bushels while the same quantity of labor, working by

hand methods, could have produced only 473,528,000 qu., that is to say, the crop would have been less by six tenths, than it actually was, if other conditions had remained unchanged and the workmen had been confined to hand methods of production. The wheat crop, by a similar calculation, would have been less by nine tenths.

If we take 100 as representing the normal supply and 100 as representing the normal price and on this basis extend Gregory King's law, which Marshall has made use of in the above quotation, so as to show the effect upon price of a decrease or increase in supply to the point of nine tenths variation we shall get the following table,-

	Supply	Price	
	1000	5.	
	500	7.8	
	333	9.	
	250	12.8	
	200	18.	
	167	26.	
	143	38.	
	125	55.	
	111	77.	
Normal	100	100.	Normal
	90	130.	
	80	180.	
	70	260.	
	60	380.	
	50	550.	
	40	780.	
	30	1080.	
	20	1460.	
	10	1950.	

In this table the numbers in the column marked price are index numbers of what the price would be with supply above or below the

normal, as indicated. To illustrate: The Indian corn crop of 1894 would have been six tenths less than it was had the production been by hand method. The Indian corn crop of 1894 is, therefore, represented by the supply number "250", its price by "12.5." But 12.5 is just about eight times less than the normal. In other words, counting the Indian corn crop of 1894 as the only "corn" in the market and the production as only that which would have resulted from the same labor by hand method, demand would have so pressed upon supply that the price would have been about eight times greater than it was and Indian corn instead of selling at 30¢ per bushel would have sold at $2.40 per bushel. The supply number for wheat in 1896 would have been 1000, its price index number, 5, or twenty times below the normal and wheat which sold at 80¢ would have sold at $16.00 per bushel.

It should be noted that King did not exclude the probability of additional workers as the demand increased. The problem, as stated above, does exclude additional workers. This exclusion would operate to make the figures in the results rather higher than lower. We may say, therefore, caeteris parious, the introduction and use of machinery has lowered the price of Indian corn about eight times and the price of wheat about twenty times below what it otherwise would have been.

Of course it will be recognized that most laws are true only "within limits" and that King's law is no exception to the general rule, so that even assuming his figures to be exact it does not

follow that so great an extension of the law as has been shown above would be true. Still it is an indication of the truth and as such the showing is believed to be valuable.

MACHINERY AND LABOR.

What is the effect of the use of farm machinery upon farm labor? Before considering this question directly we must note a change that has been going on in the character of farm work.

(The report of the Commissioner of Labor, already referred to, shows that along with the increased use of machinery there has been also, in nearly every kind of farm production, an increased number of different persons employed. For example in 1855 for the production of 40 bushels of "corn, shelled, stalks, husks and blades cut into fodder," six different persons were required. In 1894 to do the same work 25 different persons were required. In 1829-30 to produce 20 bushels of wheat four different persons were required; in 1895-96, 10 different persons were required. This change could not have taken place without the introduction of machinery and it is therefore to be attributed, indirectly at least, to the use of machinery. But immediately, and for the most part, it is doubtless due to a more methodical division and specialization of labor.) This may be indicated from the data for the wheat production just referred to. By hand method only "laborers" were employed. By machine method there were employed a separator man, a header-tender, engineers and firemen. These men are not to be classed as ordinary "laborers." Their work

requires a higher grade of intelligence. These men doubtless confine themselves to their special lines of work throughout the season, moving about from farm to farm for employment. In this way the business of the farmer has changed much in the last hundred years and is probably now changing even more rapidly than at any previous time. A hundred years ago the farmer was an agriculturalist. He raised grain and stock as now, to be sure, but he also provided, for example, his own meats. His wife and daughters spun and wove the family clothing from wool grown on the farm. When he needed a threshing machine he took a pole of convenient length, fastened another shorter one to one end by means of a thong and the "machine" was complete. Less than a hundred years ago the French settlers in what is now the state of Illinois used home-made carts that had not a particle of iron about them. The farming establishment of that day was a self-sufficing one. But now conditions are otherwise. The farmer is no longer an agriculturalist. He is an agronomist and is almost as much dependent on the business of others for what he shall eat or wear or use as is the average resident of a large city. Little by little a great part of the work of the old-time farmer has been specialized and taken from him. The successive Census Reports show a strong relative decrease in the number of agriculturalists. But if we add together and classify as agriculturalists all the people now engaged in the various labors that formerly were done on the farms, we shall find that the falling off of agriculturalists has been comparatively slight. The work has

only been differentiated, and specialized and transferred from the country to the town.) We must expect more of this in the future.

SAVING OF LABOR.

The first and most obvious effect of the use of machinery is that it saves labor. We have found that in the production of the wheat crop of 1896, for example, there were expended 7,092,419 day's-work. To have produced the same crop by the methods of 1829-30 would have required an expenditure of 127,057,891 day's-work. The difference, 119,965,472 day's-work, or 94.4%, has been saved by the use of machinery. Making similar calculations for each of the crops considered, we get the following comparative table,-

DAY'S-WORK NECESSARY TO PRODUCE

	by hand method			by machine method			days-work saved by machinery	
	crop of	by methods of	days-work	crop of	by methods of	days-work		
Corn	1894	1855	117467098	1894	1894	45873025	71614073	60.9%
Wheat	1896	1829-30	127057891	1896	1896-6	7092419	119965472	94.4%
Oats	1895	1850	105810554	1895	1895	9050463	96759891	91.4%
Rye	1895	1847-48	6855143	1895	1894-5	2759145	4115998	60.0%
Barley	1896	1829-30	14771515	1896	1895-6	627256	14144259	95.7%
Potato	1895	1866	16066560	1895	1895	5131852	10934728	68.0%
Hay	1895	1850	99257213	1895	1895	18256783	80000430	81.6%
			487305774			88770923	397564851	81.5%

The table shows that the saving of labor in the production of the different crops considered varies from 60 to 95.7%. The saving on all of the crops is 81.5%. It is probable that the saving of labor by the use of machinery in other lines of farm work is not so great as in the crops considered. 90% would doubtless be too high for the

saving in a crop of beans or buckwheat but the saving even in such crops must be considerable. Whether the proportion of labor saved in the farming industry is equal to that in other industries may be questioned. But there is at least a very close relation and interdependence between the several branches of industry in this respect. For example; railroad and other improved methods of transportation made wheat growing in the Dakotas profitable and each advance in the means of producing wheat induced better modes of transportation. Mr. David A. Wells quotes, with tacit approval, the estimates of various American and English authorities to the effect that in the thirty years preceding 1869 the saving of time and labor, by the use of machinery, varied in the different lines of work from 55-1/5% to 80%. The use of steam power alone has been estimated as having increased the efficiency of labor 600-fold.

DISPLACEMENT OF LABOR.

The second and, from an industrial point of view, by far the most important effect of the use of machinery is that it displaces labor. And the displacement is not only relative, it is absolute. The following table gives the number of days-work of man labor expended in the production of the several crops therein specified by the best methods commonly in use at the time. The earlier crops are by hand labor, the later crops are by machine labor.

DAYS-WORK OF MAN LABOR, REQUIRED TO PRODUCE THE

	crop of	by methods of	days-work	crop of	by methods of	days-work	No. of days work for later date less than for earlier date	Displacement
Wheat	1839	1829-30	25196925	1896	1895-6	7092419	19106506	75.%
Corn	1855	1855	68823092	1894	1894	45873025	22950067	33.%
Rye	1849	1847-48	3574278	1895	1894-5	2739145	835133	23.%
Oats	1839	1830	20383409	1893	1893	9050443	11332966	55.%
Barley	1839	1829-30	860740	1896	1895-6	627256	233484	27.%
Potato	1866	1866	5794557	1895	1895	5131852	662685	11.%
Hay	1849	1850	29176466	1895	1895	18256783	10919683	57.%
			153811447			88770923	66040524	42.9%

The number of days work expended to produce the several crops of these products by hand method was 153,811,447. To produce the later crops by machine required only 88,770,923 days-work. The displacement was 66,040,524 days work or 42.9%. This is the absolute displacement. Relative to production, the displacement is as many times 42.9% as the quantity produced by machine method was times greater than the quantity produced by hand method.

THE DISPLACED LABOR-POWER.

What has become of the displaced labor? It has gone partly into each of the three ways possible for it to go,--leisure, or other farm work, other occupations. That some would go to leisure seems fairly evident. Suppose that by some means, without cost to themselves and without disturbing other classes of society, the farmers of today could have machines to do all their work. They would then secure the same products and income without work. Those who were content to main-

tain only their former condition would rest with the income so secured. Those who were not so content and yet preferred to remain on the farm would seek to better their condition by means of other farm work. Dr. Bensing in a recent work, "Der Einfluss der Landwirtschaftlichen Maschinen," has shown that, when farmed under the three-field system and by hand methods, to do the year's work on a farm of about 180 acres required 573 days work of men and 139 days work of women. It took practically the whole of the time of two men and nearly half the time of one woman to care for 60 acres of rye and 60 acres of oats. They had little time for anything else. This appears evident when one considers that 450 days work were needed to do the threshing and cleaning of the grain. The farmer of today does not spend 450 days work in threshing and cleaning the rye and oats crops from 120 acres of ground. A very few days-work completes the job and he now has time to fence his fields, to drain them, to fertilize them, and to improve his home. It is largely labor-saving by machinery that has made the well-improved farm of today a possibility, and this too, generally, without requiring farm work by women at all. Those who left the farm would drift into those other occupations where their services were more needed. In support of this last proposition we have the following statistical evidence,-

PERCENTAGE OF MALES OVER TEN YEARS OF AGE ENGAGED IN GAINFUL OCCUPATIONS IN

		Agr. Fish. and Mining	Prof. Serv.	Domestic and Personal	Trade and Transp.	Mfg. and Mech.
United States	1890	44.28	3.36	14.31	16.46	21.59
	1870	53.84	2.61	12.55	11.34	19.66
New Jersey	1890	15.99	3.40	17.17	24.24	38.67
	1870	26.79	2.94	18.93	18.57	32.97
Indiana	1890	50.41	3.77	13.79	13.62	18.41
	1870	62.69	2.89	9.65	8.70	16.07
Illinois	1890	38.46	3.58	15.19	19.70	23.07
	1870	56.56	2.96	11.87	11.89	16.72
Nebraska	1890	51.35	3.78	11.19	18.24	14.72
	1870	55.23	3.07	17.41	11.36	12.93
Percentages for females, as above.						
United States	1890	17.36	7.96	42.60	5.84	26.24
	1870	21.62	5.02	53.	1.08	19.28
New Jersey	1890	1.27	6.08	45.30	7.81	41.54
	1870	.42	4.28	61.12	2.27	31.91
Indiana	1890	9.83	12.27	45.98	6.22	25.70
	1870	1.38	10.29	75.08	.46	12.79
Illinois	1890	6.45	10.96	46.40	9.71	26.48
	1870	1.64	10.19	72.95	.85	14.37
Nebraska	1890	8.11	16.99	46.14	8.27	18.49
	1870	1.69	9.19	78.77	.16	10.19

In the following table the percentage increase in each class of occupations during the period 1870-1890, as indicated by the preceding table, is represented by a plus quantity; the percentage decrease by a minus quantity. The statistics are now simplified to our purpose and the sum of the plus quantities equals the sum of the minus quan-

tities. The table represents therefore, simply yet completely the shifting of the "gainful occupation" class within the several subclasses.

Changes in occupations of males over 10 years of age, during the period 1870-1890 expressed in percentages of all males over 10 years engaged in gainful occupations. *

	Agr. Fish. and Mining	Prof. Services	Domestic and Personal	Trade and Transp.	Mfg. and Mech.
United States	- 9.56	.75	1.76	5.12	1.93
New Jersey	-10.80	.46	-1.76	5.87	5.70
Indiana	-12.28	.88	4.04	4.92	2.54
Illinois	-18.10	.62	3.32	7.81	6.35
Nebraska	- 3.88	.71	-5.50	6.88	1.79

For females, as above.

United States	- 3.26	2.94	-11.40	4.76	6.96
New Jersey	.85	1.80	-17.82	5.54	9.65
Indiana	8.45	1.98	-29.10	5.76	12.91
Illinois	4.81	.77	-26.55	8.46	12.11
Nebraska	6.42	7.80	-30.55	8.11	8.30

No amount of argument could strengthen the conclusion presented by these figures. They show so far as statistics can show, for the nation and states named, not only that people have been leaving the farms but into what other classes of occupation they have gone. Yet we may present the same results in another and perhaps more striking way, as follows,-

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* Correction has been made in the figures for the U..S. on account of the transfer in the Census of 1890 of fishermen, lumbermen, raftsmen, miners, quarrymen and wood choppers from the class of Mfg. to Agr. F. and M. but otherwise no change has been made from the Census Report. No correction has been made for the several states.

Percentages of increase in the different classes of occupations of persons over ten years of age engaged in gainful occupations, 1870-1890,-

	Agr. Fish. and Mining	Prof. Services	Domestic and personal	Trade and Transp.	Mfg. and Mech.
United States	42	243	88	179	108
Illinois	21	136	114	206	139
Indiana	23	120	97	150	85
Nebraska	623	1291	572	1266	677
New Jersey	18	137	75	159	116

We should note in passing that this proportional decrease in the number of people engaged in agriculture is not attended with a corresponding decrease in the whole number of people engaged in gainful occupations. On the contrary there has been a steady increase in this respect, as the following table will show:

Year	Total population	In gainful occupation over 10 yrs. of age	per cent.
1870	38,558,371	12,505,923	32.4
1880	50,155,783	17,392,099	34.6
1890	62,622,250	22,735,661	36.3

MACHINERY AND THE SIZE OF FARMS.

What influence does machinery have upon the size of farms? Apparently the answer to this question is of no practical importance but it involves the very important question of whether intensive cultivation on a large scale, or the application of machine power, is profitable.

The Census reports for 1850, 1860, 1870, 1880 and 1890 give the average acreage of farms as 203, 199, 153, 134, 137 respectively. In each instance, except the last one, there has been a fall from the previous figure and the rise in the last case is comparatively slight. Plainly enough the tendency in this country, has been toward smaller farms with a present, possibly, reactionary tendency.

Capital may be applied to land in three different ways--expenditure for labor, expenditure for improvement of the soil, as for manures, drainage, etc., and expenditures for machinery. Other things being equal, the more capital per acre the more intense the cultivation. For the purpose in the application of capital and the distinctive feature of a purely intensive cultivation is adaptation of soil to crop rather than of crop to soil. With a given capital, the smaller, therefore must be the area under intensive cultivation. But because all the ways of applying capital together operate toward a reduction of farm areas it does not follow that the operation of each of the ways is in that same direction. We have to determine the operation of machinery-capital alone.

Capital is applied, in farm machinery, only on improved land but the farm comprises both improved and unimproved land. The Eleventh Census gives, for 1890, the number of acres of improved land in each state, the value of the agricultural implements and machinery in each state, and, for the years 1850, 1860, 1870, 1880 and 1890, with a few exceptions, the average farm acreage in each state for the dates named. From these data we may determine, for the year 1890, the value of farm implements and machinery per acre of improved land in each of the states. Arranging the results according to the value of implements and machinery per acre of improved land we have the following,-

No.	State	Value of Implements and Machinery per acre of improved land	Average area of farms in 1850	1860	1870	1880	1890
1	D. C.	$8.05	103	144	56	42	31
2	N. J.	3.69	115	108	98	85	86
3	Mass.	3.58	99	94	105	87	87
4	R. I.	3.42	103	96	94	83	85
5	Penn.	2.95	117	109	103	93	87
6	N. Y.	2.84	112	106	105	99	97
7	Del.	2.40	158	151	138	125	113
8	Mich.	2.24	129	115	101	90	86
9	Conn.	2.23	106	99	93	80	86
10	Utah	2.12	51	25	30	69	126
11	N. H.	2.08	116	123	122	116	119
12	Wis.	1.96	148	114	114	114	115
13	Idaho	1.93	---	---	186	174	197
14	Md.	1.91	212	190	167	126	121
15	La.	1.89	372	537	247	171	138
16	Ariz.	1.88	---	---	127	177	910
17	Me.	1.80	97	103	98	102	100
18	Va.	1.78	139	135	134	137	135
19	Ohio	1.66	125	114	111	99	95
20	Minn.	1.52	184	149	139	145	160
21	Colo.	1.49	---	---	184	259	281
22	Mont.	1.48	---	---	164	267	351
23	Iowa	1.44	165	165	134	134	151

24	N. Dak.	1.42	---	215	176	218	277
25	Ind.	1.40	136	124	112	105	103
26	Ill.	1.35	158	146	128	124	127
27	Ore.	1.29	372	355	315	260	271
28	Cal.	1.20	4466	466	482	462	405
29	S. Dak.	1.20	---	---	---	---	227
30	Wash.	1.17	---	275	208	216	251
31	N. Mex.	1.10	77	278	186	125	177
32	Mo.	1.10	179	215	146	129	129
33	Wyo.	1.09	---	---	25	272	586
34	Nebr.	1.08	---	226	169	157	190
35	Tenn.	1.06	261	251	166	125	116
36	Ark.	1.03	146	245	154	128	119
37	Fla.	1.01	371	445	232	141	107
38	Ky.	.92	227	211	158	129	119
39	N. C.	.91	369	316	212	142	127
40	Miss.	.87	309	370	193	156	122
41	Kan.	.85	---	171	148	155	181
42	S. C.	.79	541	488	233	143	115
43	Okl.	.76	---	---	---	---	182
44	Nev.	.74	---	617	201	378	1301
45	Va.	.72	340	336	246	167	150
46	W. Va.	.68	---	---	214	165	142
47	Tex.	.66	942	591	501	208	225
48	Ga.	.61	441	430	338	188	147
49	Ala.	.58	289	347	222	139	126

One would naturally expect the eastern states to rank nigh in such a showing but an inspection of the table shows that neither relative geographical location east and west nor priority of settlement determines the rank. If New Jersey, Massachusetts and Rhode Island are near the head of the list, Virginia, the Carolinas and Georgia are near the bottom. Michigan ranks 8th while Tennessee is 35th. Montana and North Dakota are ahead of Indiana and Illinois while Utah, Wisconsin and even Idaho are ahead of Maryland. Arizona outranks either Maine or Vermont. Washington and New Mexico are far above either Florida or Kentucky. As to size of farms nothing definite an-

appears, The states at the head of the list have small farms but the big farms are by no means collected at the opposite extreme. It is not, however, so much the absolute size of farms, with or without machinery, with which we are concerned. It is rather the operation or influence of this particular form of capital upon size of farms.

We may fairly assume that no state, having once adopted an implement or machine has put that particular form of machinery away, to any considerable extent, for a more primitive form. The acquisition of better farm machinery has therefore been continuous in each of the states. If then we can discover a concomitant variation between the supply of farm machinery and the increasing or decreasing movement in the size of farms, we may safely conclude that there is at least a causal connection between the two. Repeating now the last preceding table except that in place of showing the average acreage in each state at each Census taking we denote each fall in average acreage from that of the preceding Census by a minus sign and each rise by a plus sign (here denoted by an x) we will have the following,-

No.	State	Value of Implements and Mach. per acre of improved land	Rise or fall in 1860	1870	1880	1890
1	D. C.	8.05	x	-	-	-
2	N. J.	5.69	-	-	-	x
3	Mass.	5.58	-	x	-	
4	R. I.	5.42	-	-	-	x
5	Penn.	2.95	-	-	-	-
6	N. Y.	2.84	-	-	-	-
7	Del.	2.40	-	-	-	-
8	Mich.	2.24	-	-	-	-
9	Conn.	2.23	-	-	-	x
10	Utah	2.12	-	x	x	x

11	N. H.	2.08	x	-	-	x
12	Wis.	1.96	-			x
13	Idano	1.93			-	x
14	Md.	1.91	-	-	-	-
15	La.	1.89	x	-	-	-
16	Ariz.	1.88			x	x
17	Me.	1.80	x	-	x	-
18	Vt.	1.78	-	-	x	-
19	Ohio	1.66	-	-	-	-
20	Minn.	1.52	-	-	x	x
21	Col.	1.49			x	x
22	Mont.	1.48			x	x
23	Ia.	1.44	-	-		x
24	N. D.	1.42		-	x	x
25	Ind.	1.40	-	-	-	-
26	Ill.	1.35	-	-	-	x
27	Ore.	1.29	-	-	-	x
28	Cal.	1.20	-	x	-	-
29	S. D.	1.20				
30	Wash	1.17		-	x	x
31	N. Mex.	1.10	x	-	-	x
32	No.	1.10	x	-	-	
33	Wyo.	1.09			x	x
34	Nebr.	1.08		-	-	x
35	Tenn.	1.06	-	-	-	-
36	Ark.	1.03	x	-	-	-
37	Fla.	1.01	x	-	-	-
38	Ky.	.92	-	-	-	-
39	N. C.	.91	-	-	-	-
40	Miss.	.87	x	-	-	-
41	Kan.	.85		-	x	x
42	S. C.	.79	-	-	-	-
43	Okl.	.76				
44	Nev.	.74		-	x	x
45	Va.	.72	-	-	-	-
46	W. Va.	.68			-	-
47	Tex.	.66	-	-	-	x
48	Ga.	.61	-	-	-	x
49	Ala.	.58	x	-	-	-

There are 115 minus signs on the table as against 47 plus signs. There are 13 states that yield invariably minus; there is no state yielding all plus signs, and unless we put a plus and minus sign where no change occurs in the case of Wisconsin then Utah is the

only state yielding three plus signs. The first nine states yield 30 minus and 5 plus signs. The last nine states yield 22 minus and 6 plus signs. The intermediate states yield 67 minus and 38 plus. The first fifteen states yield 42 minus and 13 plus, the last fifteen states 43 minus and 9 plus. The intermediate states yielding 34 minus as against 25 plus. However we may look at the table the minus signs as compared with the plus signs are not only strongest at the extremes of the table but the two extremes are pretty evenly balanced. The plus signs, indicating a tendency to increase the size of the farms, are relatively much stronger in the middle of the table and we seem to be no nearer a conclusion than before.

A further examination of the table shows that in every instance where a state has two plus signs together they arise from the last two Census takings. Selecting the states so distinguished we get the following list to-wit,-

No.	State	Value of Implements and Mach. per acre of Improved land	1860	1870	1880	1890
10	Utah	2.12	-	x	x	x
16	Ariz.	1.88			x	x
20	Minn.	1.52	-	-	x	x
21	Colo.	1.49			x	x
22	Mont.	1.48			x	x
24	N. D.	1.42		-	x	x
30	Wash.	1.17		-	x	x
33	Wyo.	1.09			x	x
41	Kan.	.85		-	x	x
44	Nev.	.74		-	x	x

Ten states in all. They are from the middle of the table, no one of them ranking higher than 10th, none lower than 44th.

Making a similar list of all states yielding minus signs by the last two Census takings we have the following,-

No.	State	Value of Implements and Mach. per acre of Improved land	1860	1870	1880	1890
1	D. C.	8.05	x	-	-	-
5	Penn.	2.95	-	-	-	-
6	N. Y.	2.84	-	-	-	-
7	Del.	2.40	-	-	-	-
8	Mich.	2.24	-	-	-	-
14	Md.	1.91	-	-	-	-
15	La.	1.89	x	-	-	-
19	Ohio	1.66	-	-	-	-
25	Ind.	1.40	-	-	-	-
28	Cal.	1.20	-	x	-	-
35	Tenn.	1.06	-	-	-	-
36	Ark.	1.03	x	-	-	-
37	Fla.	1.01	x	-	-	-
38	Ky.	.92	-	-	-	-
39	N. C.	.91	-	-	-	-
40	Miss.	.87	x	-	-	-
42	S. C.	.79	-	-	-	-
45	Va.	.72	-	-	-	-
46	W. Va.	.68			-	-
48	Ga.	.61	-	-	-	-
49	Ala.	.58	x	-	-	-

Twenty-one states in all. They are from all parts of the table, especially from the two extremes, and the logical conclusion is that machinery is the cause of the diminishing tendency in the size of the farms under both conditions: in the higher ranking states because of its presence; in the lower ranking states because of its absence. But it is clearly absurd to say that machinery by its absence caused a decrease in the size of farms. There has been a decrease in the size of southern farms. We know it was not caused by machinery. Further than this does not appear from our investigation and, for the pur-

poses of this investigation, we do not care what the cause may have been. We therefore drop the eleven lowest ranking states, having a large negro population, thereby changing the field of investigation from the whole country to only Northern States and in so doing not only simplify our problem but confine it to a field where the labor element is practically homogenous---the negro population in the remaining groups of states being small and pretty evenly divided.

The inquiry is now limited to a comparison of the two groups of 10 states each. From each of these groups we will throw out one state because of extraordinary variations in the average size of their farms, Utah from the one group, California from the other. We have now left two opposing groups, with their several average acreage in 1890, as follows,-

	No.	State	Value of Implements and Mach. per acre of Improved land	Average size of farms in 1890	1860	1870	1880	1890
	1	D. C.	8.05	31	x	-	-	-
	5	Penn.	2.95	87	-	-	-	-
	6	N. Y.	2.84	97	-	-	-	-
	7	Del.	2.40	113	-	-	-	-
8	8	Mich.	2.24	86	-	-	-	-
	14	Md.	1.91	121	-	-	-	-
	15	La.	1.89	138	x	-	-	-
	19	Ohio	1.66	93	-	-	-	-
	25	Ind.	1.40	103	-	-	-	-

	No.	State	Value of Implements and Mach. per acre of Improved land	Average size of farms in 1890	1860	1870	1880	1890
	16	Ariz.	1.88	910	-	-	x	x
	20	Minn.	1.52	160	-	-	x	x
	21	Colo.	1.49	281			x	x
	22	Mont.	1.48	351			x	x
24	24	N. D.	1.42	277		-	x	x
	30	Wash.	1.17	231		-	x	x
	33	Wyo.	1.09	586			x	x
	41	Kan.	.85	181		-	x	x
	44	Nev.	.74	1301		-	x	x

The middle ranking state in the first group is No. 8. The middle ranking state in the second group is No. 24. These numbers are fairly indicative of the wide difference between the groups. Reference to the ranking numbers of the several states in the groups shows that only two states in the first group have as low a rank in the matter of agricultural implements and machinery per acre as the highest ranking state in the second group. In the matter of the use of machinery they may be fairly classed as non-competing groups and in the matter of average farm acreage the difference is even more marked. For the largest average sized farm in the first group is smaller than the smallest in the second group. The average size of the farms in the first group as determined by ranking the states according to their average farm acreages in 1890 and taking the middle ranking state, is 97 acres; for the second group it is 281 acres. As determined by arithmetical average i. e. an average of averages which would be good only as between the states, the showing is for the first group 95 acres, for the second 475 acres. However we may look at the fig-

ures the same showing is made. Other conditions being equal, in the states using much machinery the tendency is to decrease the size of farms; in the states using little machinery the tendency is to increase the size of farms. There is a concomitant relationship between these two phenomena and therefore a causal relation.

If we classify the states according to the tendency to increase or decrease the size of farms as shown by the last Census alone, and drop out of account as before Utah, California and the group of southern states having little or no machinery there will appear eleven states showing a decreasing tendency and 21 states showing an increasing tendency. The first group will be changed only by the addition of two states, Maine and Vermont. The second group is changed by the addition of eleven states New Jersey, Rhode Island, Connecticut, New Hampshire, Wisconsin, Idaho, Iowa, Illinois, Oregon, Nebraska and Texas. The additions are chiefly from the higher ranking states--from those having most machinery. The inference is clear that in 1890 there was a strong reactionary tendency against the gradual reduction of farm areas that had been constant since 1850.

Whatever various causes may have operated to produce this reaction, the chief cause, in the opinion of the writer, has been the introduction and use of farm machinery of large capacities, as, for example, the steam plow, the combined harvester and thresher, etc. The conclusion already drawn is for the effect of all the different kinds of farm machinery with no new forms of machinery being intro-

duced. Anyone will admit that for each machine there is a minimum sized farm, below which sized farm, if we go, the machine can not be used with profit. But there seems also to be a maximum sized farm--a size beyond which to go is to necessitate the use of an additional machine of the same sort--self-binder, for instance. From two machines on one farm to two farms each with one machine, is the natural working of our inheritance laws, alienations and marginal utilities. When the first threshing machines came into use they were largely a fixture on the farm. The traveling threshing company was rather the exception. Now very few farmers have a threshing machine exclusively for their own crops. To keep a modern threshing machine in work would require a very large farm. The other farm machinery could be most advantageously used on smaller farms, and so the expanding tendency of the threshing machine lost its hold, so to speak. The size of farms relaxed to fit the smaller machinery, threshing became differentiated from other farm work and became a separate and independent business.

Will the combined harvester and thresher follow the way of the threshing machine? Undoubtedly, and for this reason, if for no other, that the standard of intelligence requisite for the management of one of these machines is higher than that for ordinary farm labor. The more intelligent workman demands constant employment at his especial work and whenever he comes into competition with inferior labor he will crowd it out.